EUCOLD - International Workshop on overflow-erosion of dams
13 – 14th December 2017 - AUSSOIS, FRANCE

ALPIQ

Raphaël LEROY – Head of civil engineering – ALPIQ

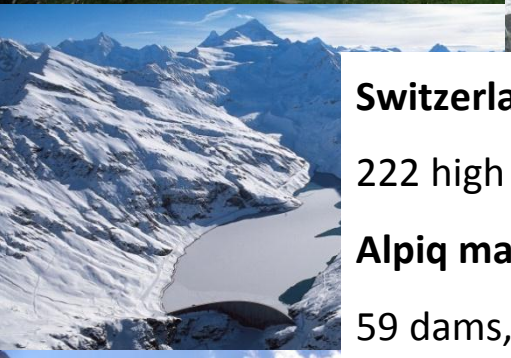
Agenda

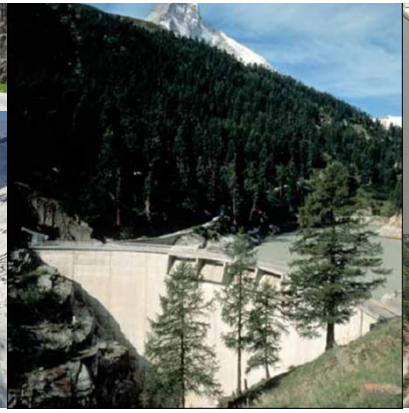
ALPIQ

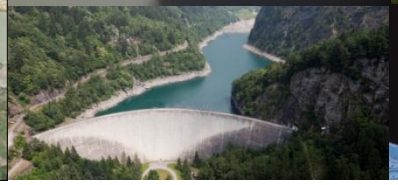
1. Dams
    - Switzerland
    - Alpiq
2. Study cases
    - Z’mutt
    - Gebidem
3. Conclusion

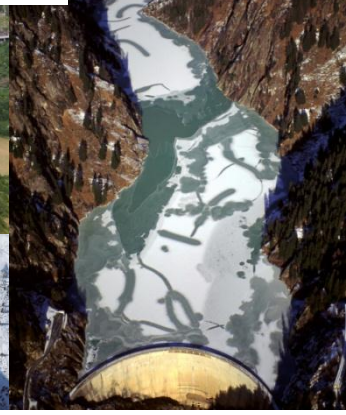







Switzerland

222 high dams, 25 higher than 100m

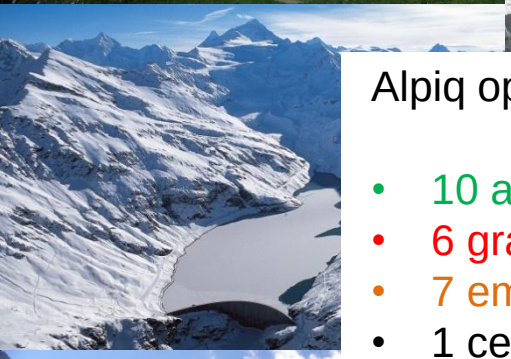
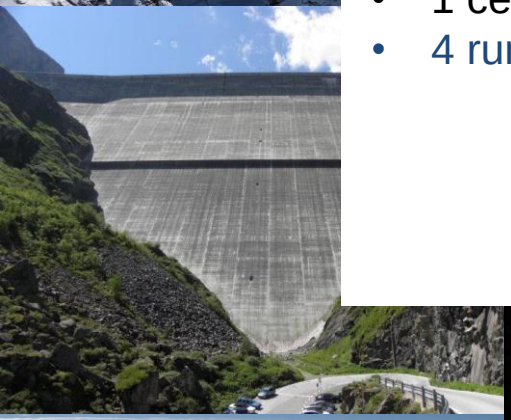
Alpiq managed

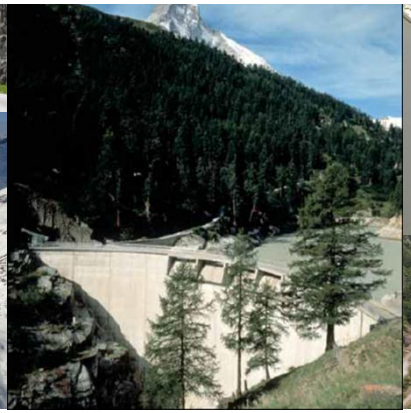
59 dams, 13 higher than 100m

Alpiq operates

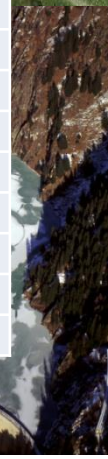
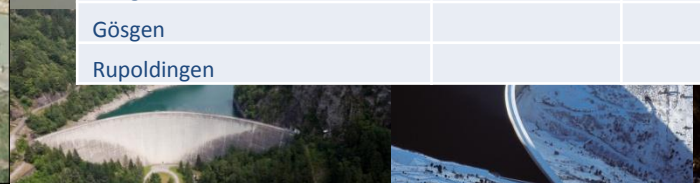
28 dams, 11 with five years control








Alpiq operates 28 dams:

- 10 arch dams
- 6 gravity dams
- 7 embankment dams
- 1 cellular gravity dam
- 4 run of river dams

Name	Height	Volume
Chargeur (Grande Dixence)	285	400
Emosson	180	227
Moiry	148	77
Hongrin Nord	123	52
Gebidem	122	9.2
Hongrin Sud	95	52
Cleuson	87	20
Vieux Emosson	77	25
Zmutt	74	0.85
Salanfe	52	40
Tourtemagne	33	0.78
Fionnay	31	0.3
Ferpècle	25	0.1
Sera	22	0.18
Les Esserts	20	0.26
La Fouly	18	0.02
Gietroz du fond	13.9	0.02
Fah	12.5	0.05
Chatelard	11	0.09
Clusanfe	11	0.005
Mottec	11	0.15
Eggen	10	0.05
Vissoie	6	0.05
Stafel	6	0.18
Flumenthal		
Gösgen-winznau		
Gösgen		
Rupoldingen		

Spillways / floods

ALPIQ

Type of spillways (24 dams)

- 18 free overflow spillways
- 4 (half) morning glory spillways
- 1 siphon spillway
- 2 unequipped (Grande-Dixence)

The catchment areas are mostly small.

The flood volumes are small and the durations are short.

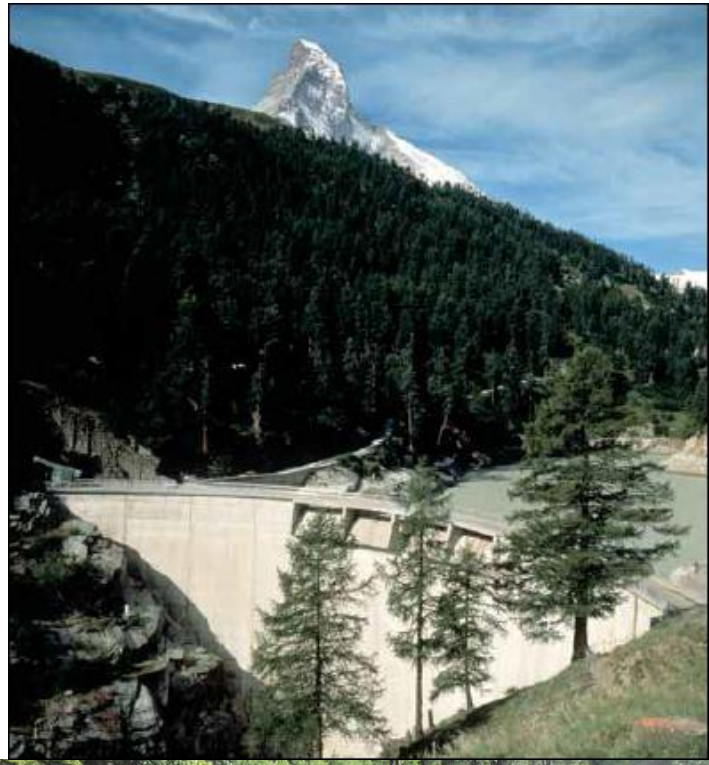
Name	Type	Particularity
Chargeur (Grande-Dixence)	/	Flood management
Emosson	free overflow spillway	side spillway
Moiry	half morning glory spillway	
Hongrin Nord	morning glory spillway	
Gebidem	free overflow spillway	impact slab/ bottom outlet
Hongrin Sud	/	
Cleuson	free overflow spillway	
Vieux Emosson	free overflow spillway	
Zmutt	free overflow spillway	overflow over the crest bridge
Salanfe	free overflow spillway	
Tourtemagne	free overflow spillway	side spillway
Fionnay	siphon spillway	fuse wall
Ferpècle	half morning glory spillway	
Sera	free overflow spillway	
Les Esserts	free overflow spillway	
La Fouly	free overflow spillway	
Gietroz du fond	free overflow spillway	
Fah	free overflow spillway	
Chatelard	free overflow spillway	
Clusanfe	free overflow spillway	
Mottec	free overflow spillway	
Eggen	free overflow spillway	
Vissoie	free overflow spillway	
Stafel	free overflow spillway	

Study case (1)
Z'mutt (Zermatt)

ALPIQ

Characteristics

- Arch dam
- Height 74 m
- Top elevation 1972,25 asl
- Crest length 144 m
- Top thickness 3 m / base width 8,8 m
- Concrete volume 32'000 m^3
- Capacity 550'000 m^3
- Free overflow spillways/capacity max 225 m^3/s
- Catchment area 52,7 km^2



Study case (1)
Floods

ALPIQ

Following the 2007 five-year control (comprehensive safety assessment): an update of the hydrology was completed in 2008
The flood flows have been re-evaluated:

Débits de crue		
Crue de projet	Q1000	311 m³/s[1]
Crue de sécurité	Q10'000	450 m³/s
	PMP-PMF	*1200 m³/s*

The 225 m³/s capacity of the spillway is insufficient to evacuate thousand-year peak flood without overtopping the crest.

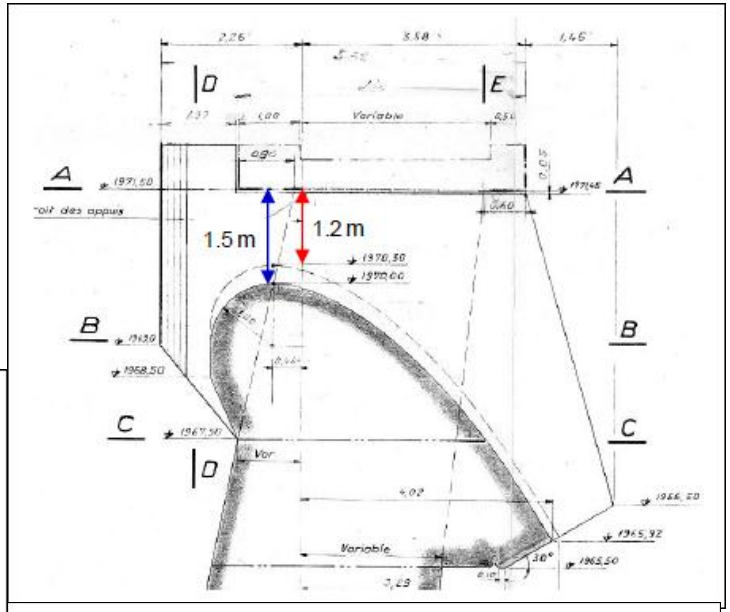
	Débit [m³/s]	Niveau de la retenue [m]	Déversement par-dessus le couronnement [m]
Crue de projet	311	1972.7	0.45
Crue de sécurité	450	1973.0	0.75

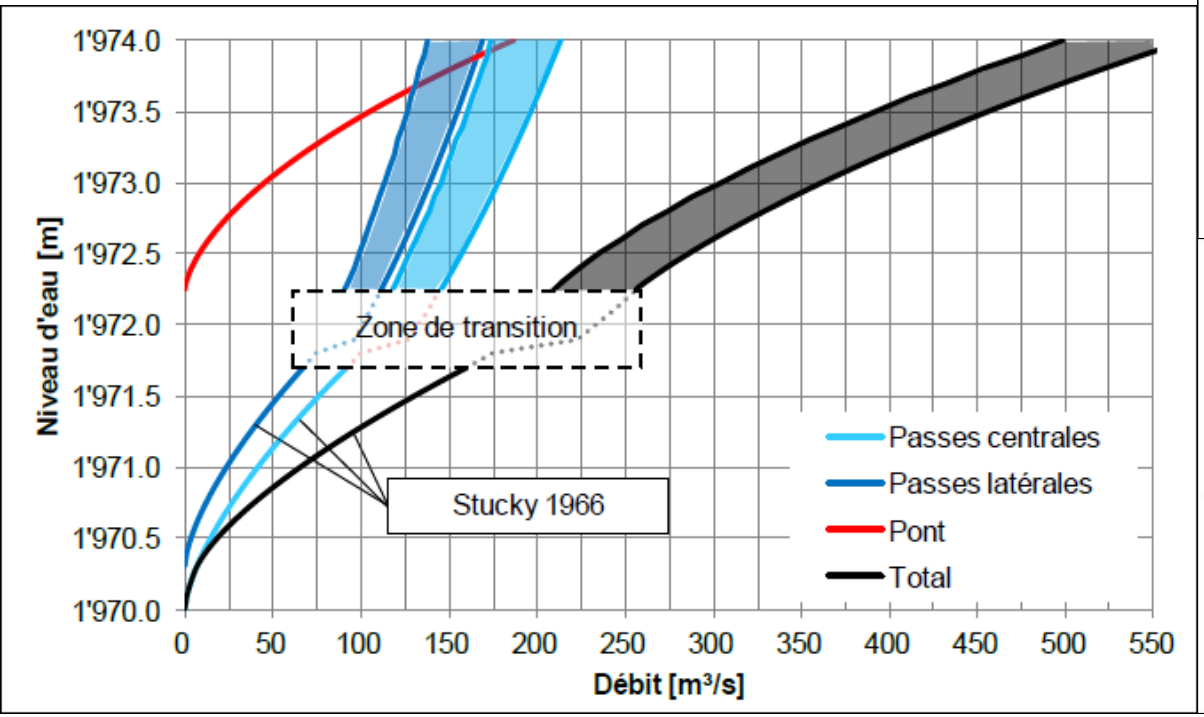
SFOE requested to update the capacity

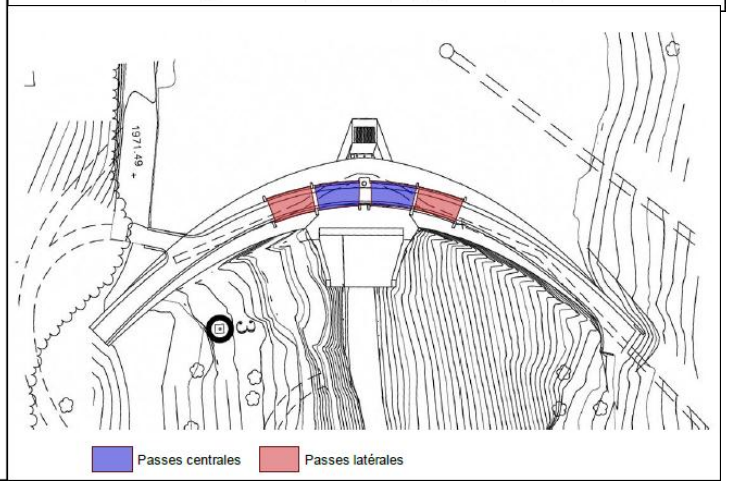
Study case (1)
Feasibility & preliminary studies

ALPIQ

Design
- Parapet
- Partial flood over the bridge
- Q10’000 without overtopping
- Numerical verification

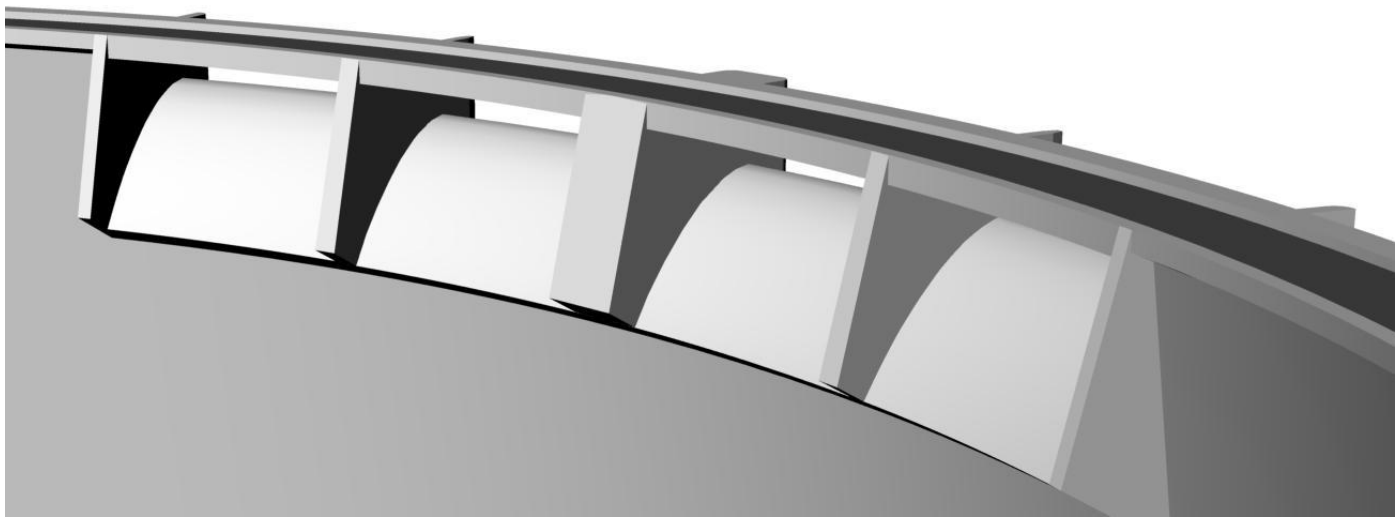


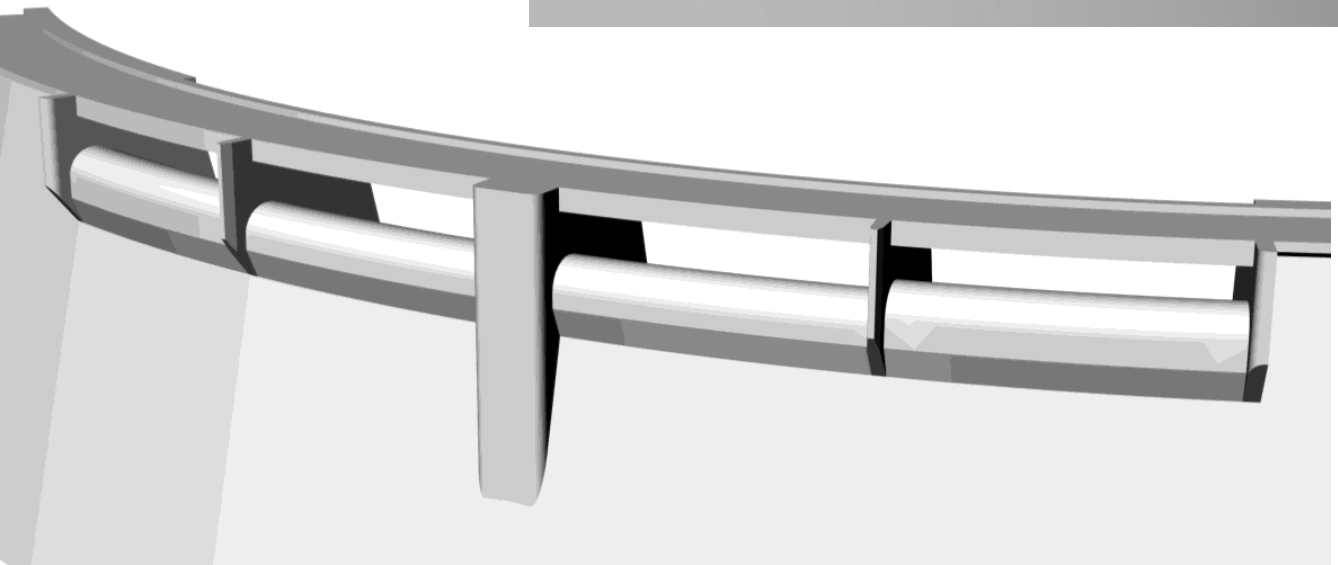




Study case (1)
3D calculation

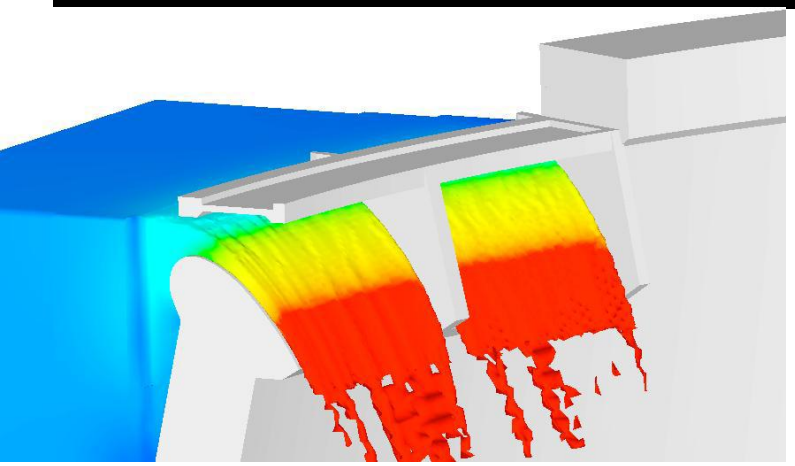
ALPIQ





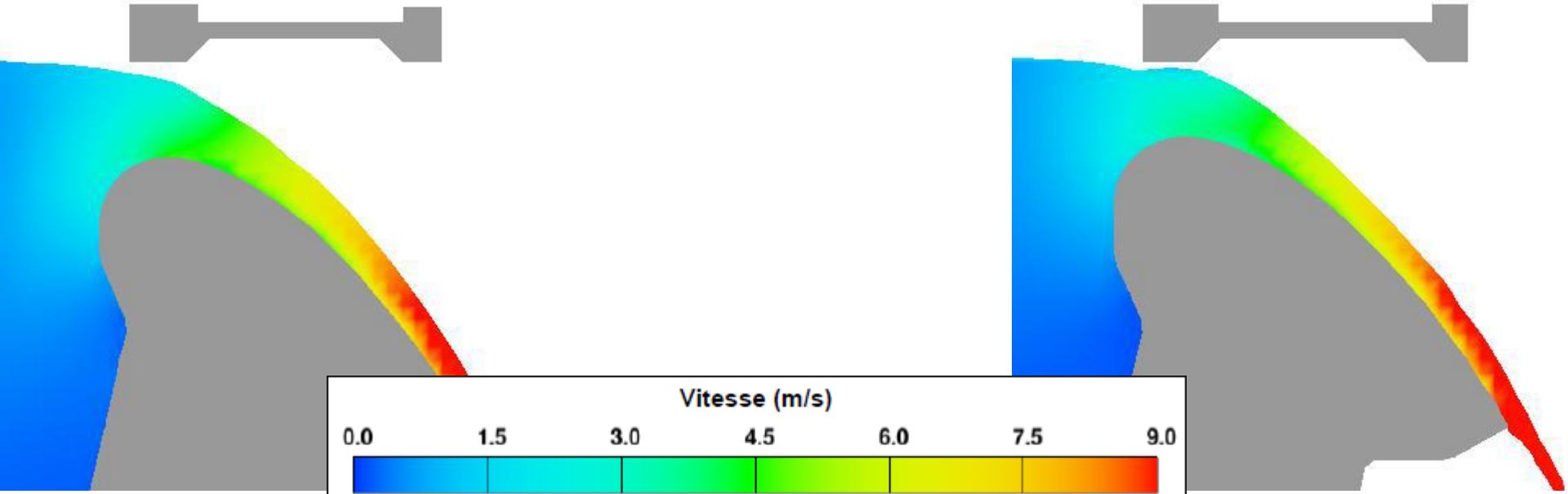
Study case (1)
3D calculation

ALPIQ



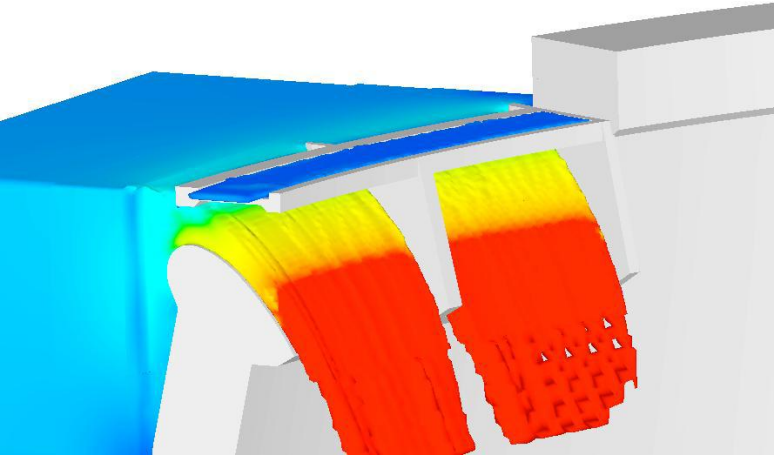
For a water level at 1'971.50 m asl:

- Free flow (139 m³/s)
- Avg water speed 3.5 m/s.



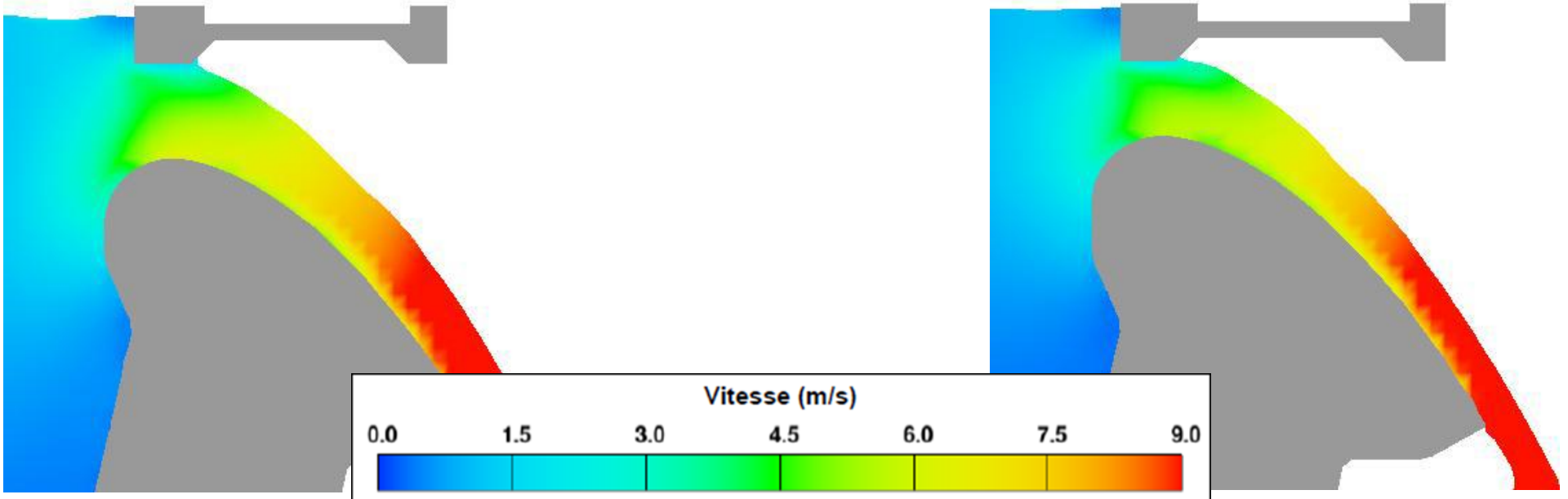
Study case (1)
3D calculation

ALPIQ



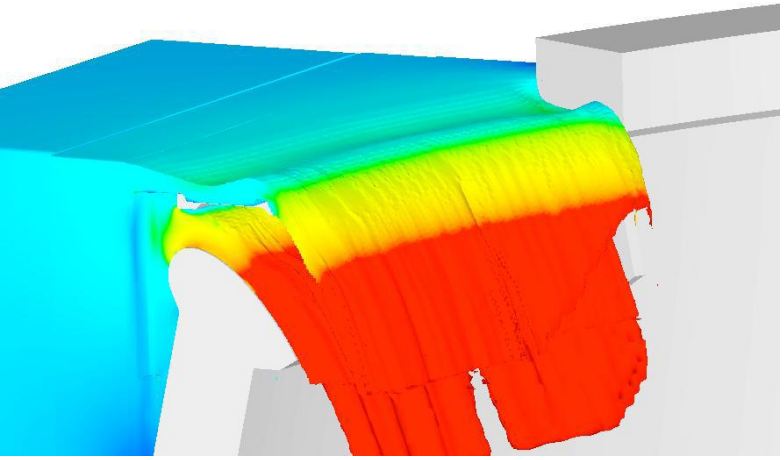
For a water level at 1'972.25 asl (bridge deck)

- Pressure flow (244 m³/s)
- Avg water speed 4.5 m/s.



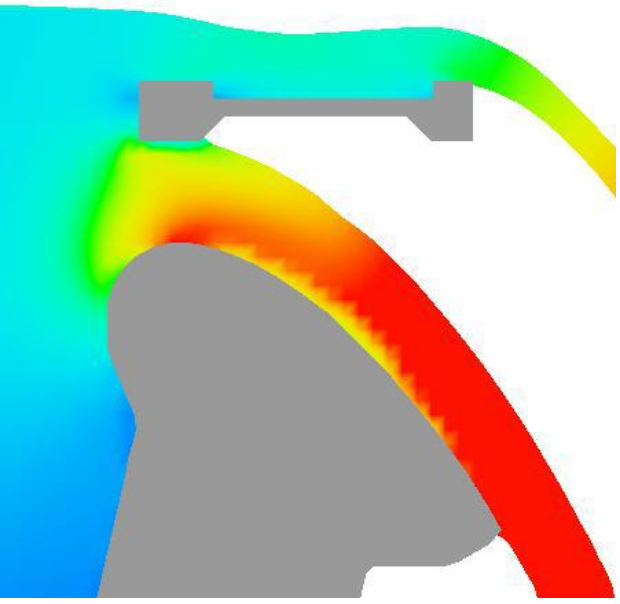
Study case (1)
3D calculation

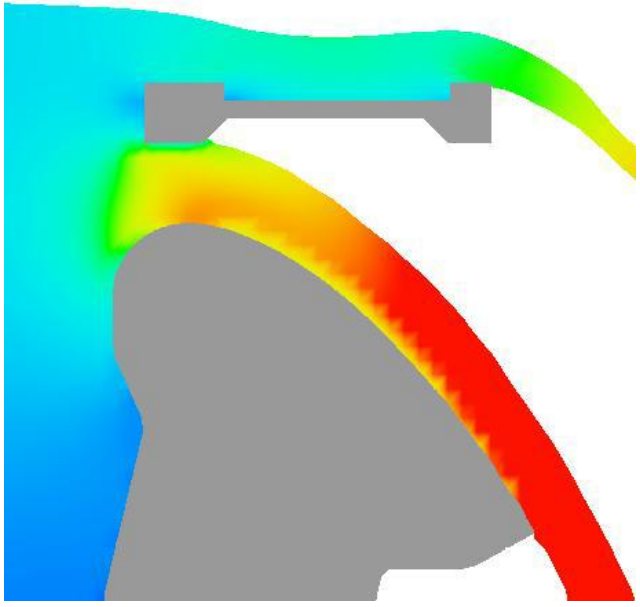
ALPIQ



For a water level at 1'973.50 asl:

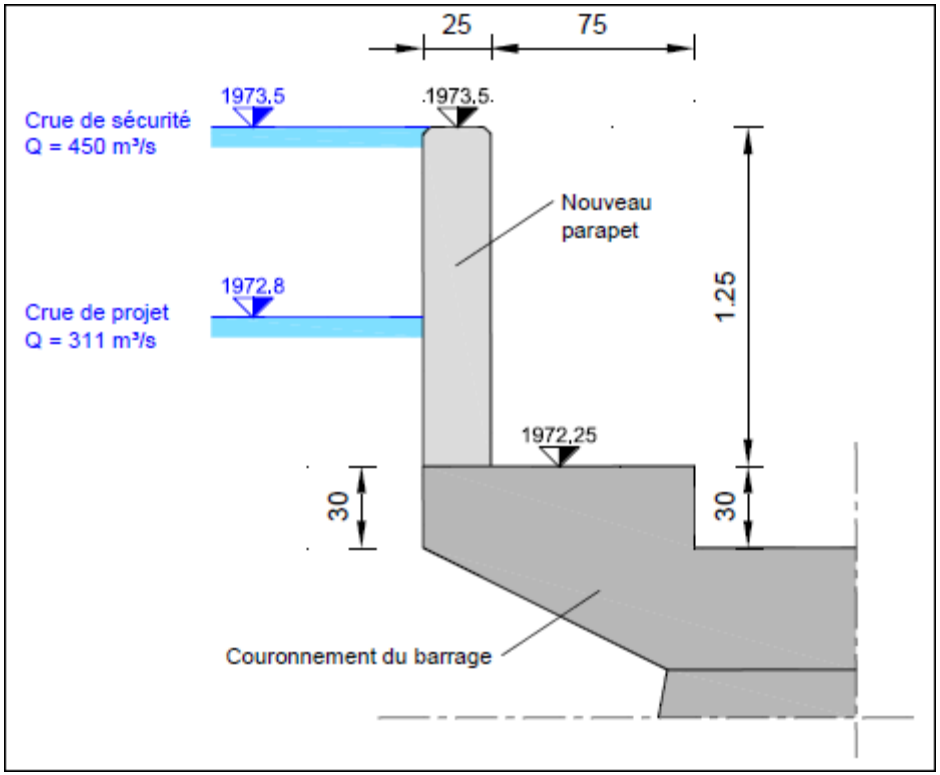
- Pressure/free flow.
- 109 m^3/s over the bridge
- 365 m^3/s on the spillway
- Avg 6.8 m/s (spillway) and 3.0 m/s (bridge)

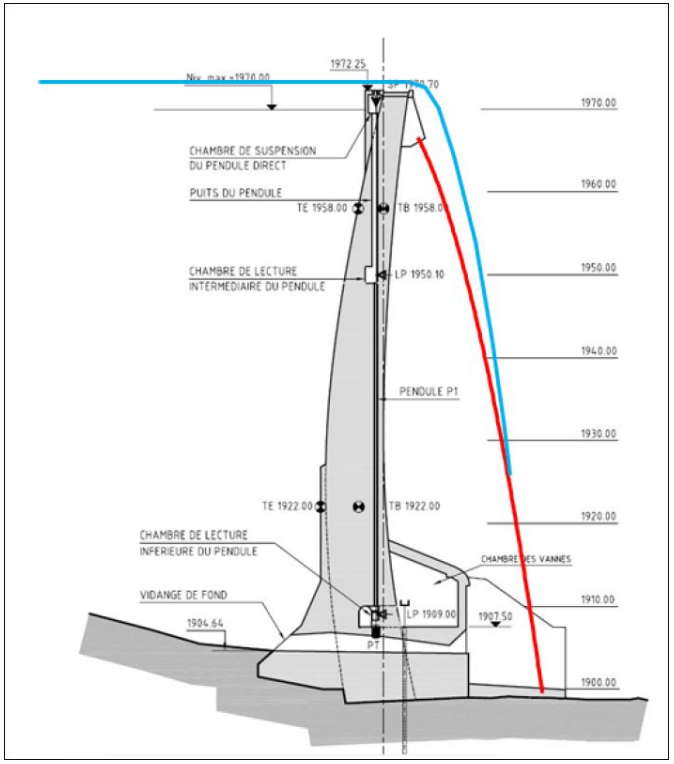




Study case (1)
Parapet design / Ballistic study

ALPIQ





A ballistic study has been conducted to evaluate the impact of the water falling from the spillway (red) and crossing over the bridge (blue).

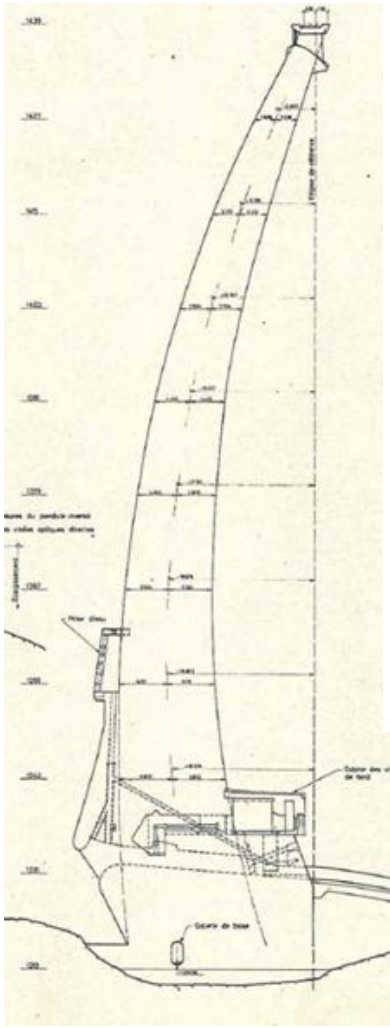
Study case (1)
Downstream and geological aspects

ALPIQ

- The future impact area will be located as currently (no downstream movement)
- No risk of large-scale destabilization

Study case (2)
Gebidem

ALPIQ



Characteristics

- Height 122 m
- Water level 1436.50 asl - top elevation 1439.00 asl
- Crest length 327 m, top thickness 3 m / base width 17.5 m
- Concrete volume 228'000 m³ (dams)
- 8'825 m³ (impact slab)
- Capacity 9’200’000 m³
- Aletsch glacier - catchment area 192,5 km²
- Average water inflow: 400 billion m³
- Average sediment inflow: 350’000 m³
- Free overflow spillways/capacity max 250 m³/s (Q1000)
- The crest has been designed for an overtopping. With a load of 0.5 m the flood can upraise till 450 m3/s.

Study case (2)
Gebidem (overflowing – sediment purge)

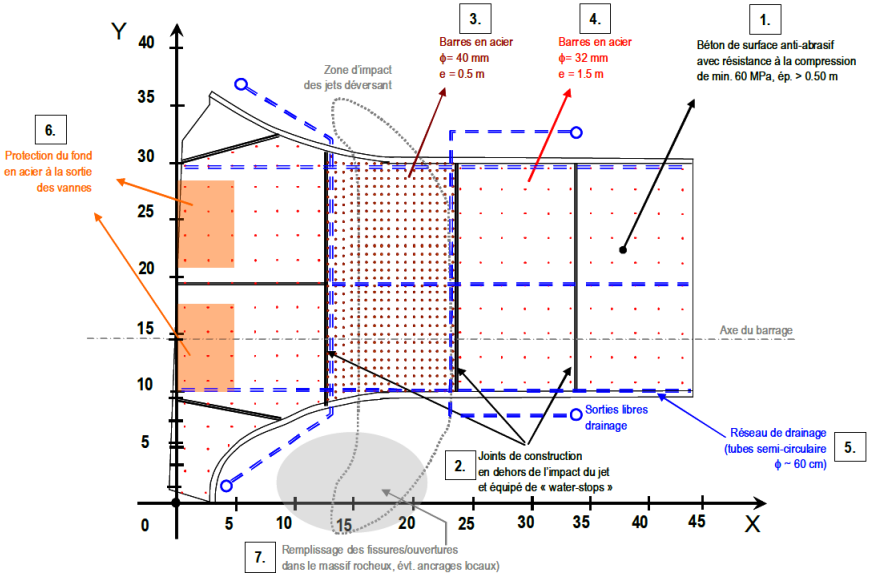
ALPIQ

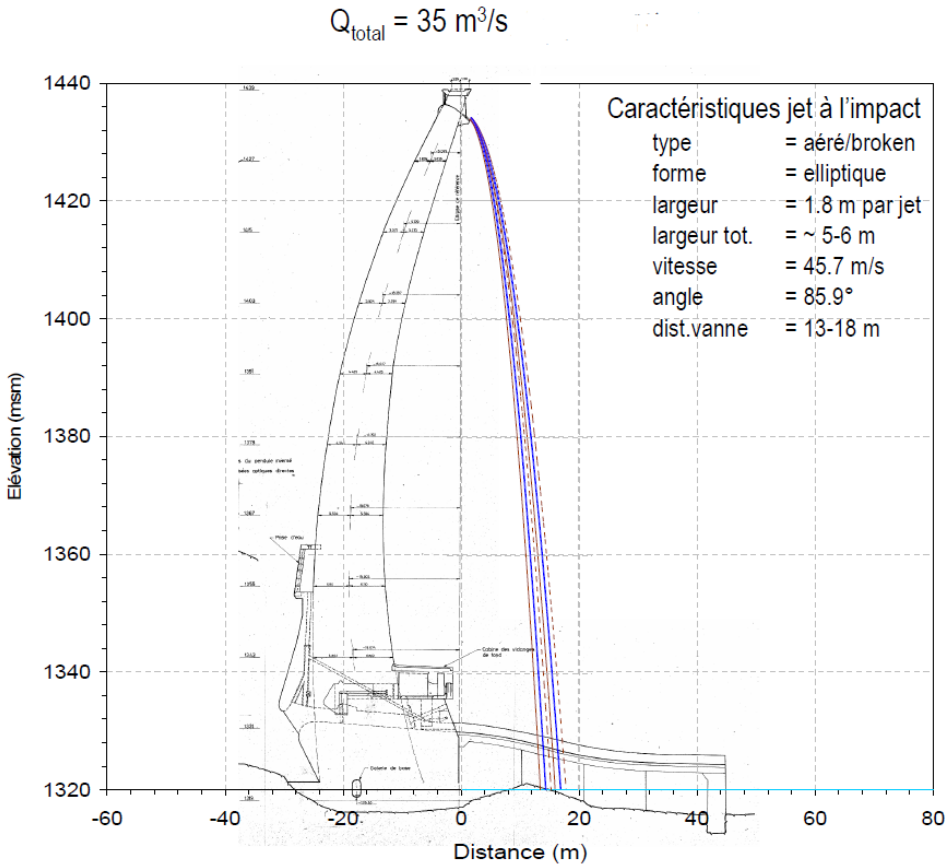
Average water inflow: 400 million m³
Average sediment inflow: 350’000 m³

Study case (2)
Gebidem

ALPIQ

The impact slab needs resistance to abrasion during the purge and resistance to impact during overflowing

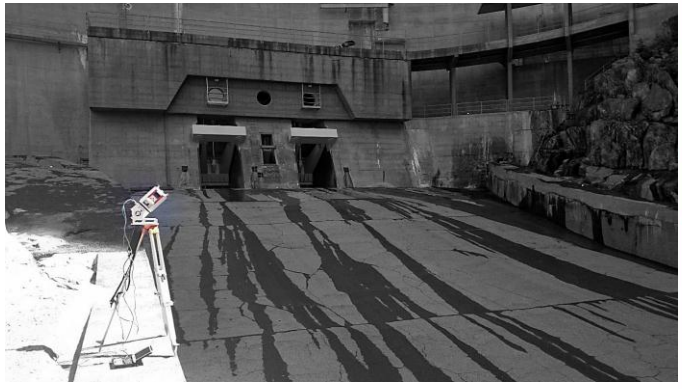


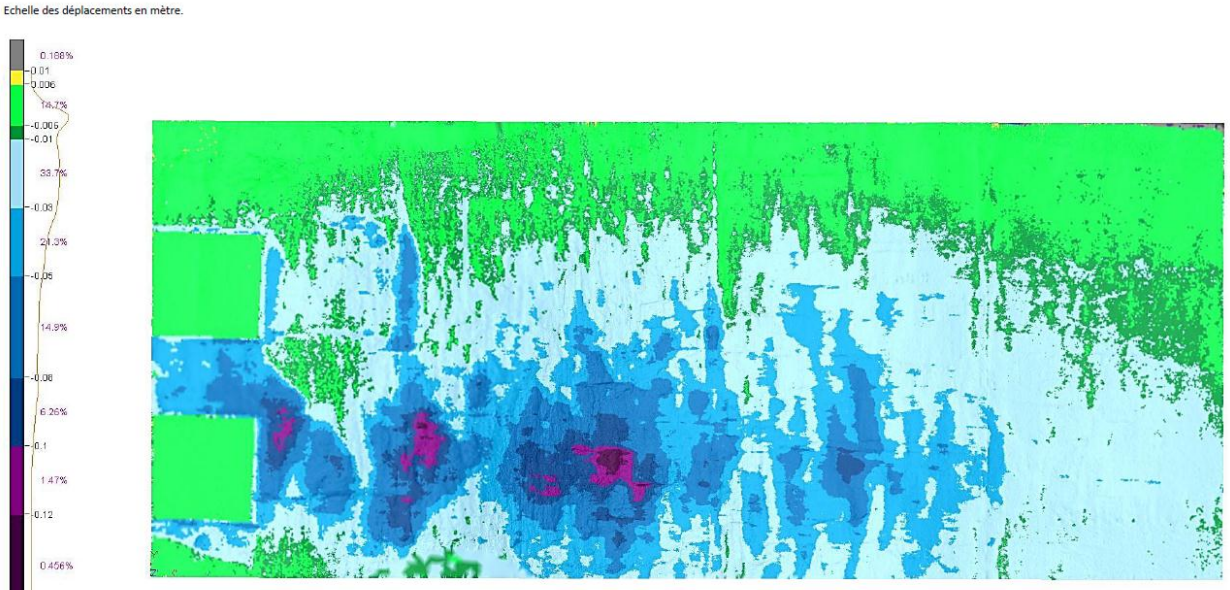


Study case (2)
Gebidem

ALPIQ

- The impact slab has been rebuilt with a very high quality concrete
  - 495 m3 C60/75 SN EN 206
  - 7 stages (17 – 127 m3)
  - basaltic aggregates 4/14 mm
  - slag cement
  - high resistance > 100 MPa
  - high abrasive criteria
  - metallic fibers
- A laser scanner measurement is performed after each purge.

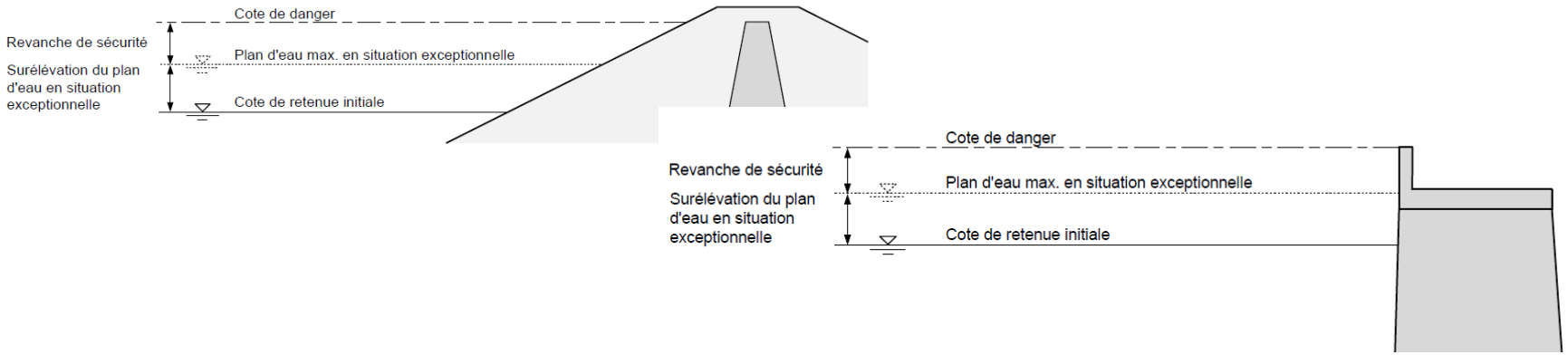




Conclusion
Alpiq's needs / owner's point of view

ALPIQ

- 2016 - new Swiss regulation



- Re-evaluation of the flood

→ Overtopping of the dam can be a real opportunity
→ Parameters could be:
  → duration of the flood
  → geology
  → shape of the foundation

ALPIQ

Thank you very much

Raphaël LEROY
Chemin de Mornex 10
CH – 1003 Lausanne

Tél: +41 21 341 25 54
raphael.leroy@alpiq.com